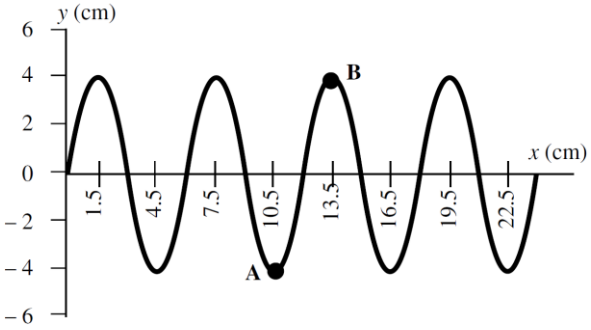
Physics

Unit 7: Waves and Sound

1. *Know meanings of reflect, interference, beats, constructive, destructive, frequency, superposition, wavelength, standing wave, fundamental frequency, harmonics (i.e. 1st harmonic, 2nd harmonic), overtones (i.e. 1st overtone, 2nd overtone), resonate.*
2. *Be able to classify waves by type (longitudinal, transverse, or both).*
3. *Know the value of the threshold of hearing.*
4. *Know how frequency and pitch are related.*
5. *Know how decibels and loudness are related.*
6. *Know what affects the speed of a wave ($v = f\lambda$ and all the speed formulas)*
7. *Know some drawings to represent standing waves in open and closed tubes.*
8. *How are standing waves produced?*
9. *How are beats produced?*
10. *What happens when two wave pulses traveling opposite directions meet?*
11. *Do waves: move energy? Move matter from place to place? Have a traveling disturbance?*
12. *What is the λ for a wave with a speed of 10 m/s and a period of 40 s?*
13. *A wave has a frequency of 30 Hz and a speed of 60 m/s. What is the wavelength of the wave?*
14. *In the following graph, what is the amplitude, wavelength and frequency of wave A is its speed is 5 cm/s?*



15. *A submarine sends out a sonar ping. The return echo is heard 20 s later. If the speed of sound is 1522 m/s, how far away is the reflecting surface?*
16. *The intensity of a spherical wave 5 m from the source is 200 W/m^2. What is the intensity at a point 10 m away from the source?*
17. *The decibel level of rock concert is 120 dB relative to the threshold of hearing. Determine the sound intensity produced by the concert.*
18. *A car moving at constant speed passes a boy playing a concert A (440 Hz) on an instrument. After the car has passed the driver hears the note as a concert E (330 Hz). How fast was the car going (speed of sound = 343 m/s)?*
19. *A car moving at 50 m/s approaches a train whistling. The train is moving towards the car at a speed of 10 m/s. The whistle is set at 200 Hz. What is the frequency heard by the driver of the car?*
20. *A guitar string produces 10 beats/s when sounded with a 440 Hz tuning fork and 5 beats/s when sounded with a 445 Hz tuning fork. What is vibrational frequency of the string?*
21. *A 2-m long string vibrates in 4 segments. The wave speed is 40 m/s. What is the frequency of vibration?*
22. *A 2-m long string vibrates in 4 segments. The wave speed is 40 m/s. What is the lowest possible frequency for standing waves on this string?*
23. *Determine the shortest length of pipe, open at both ends, which will resonate at 440 Hz. The speed of sound is 343 m/s.*
24. *A spring is used on a jumping toy. The bottom of the toy has a suction cup that keeps the spring compressed. If the suction cup supplies 15 N of force to keep the spring compressed 3 cm, what is the spring constant?*
25. *The -string on a certain guitar is under 100 N of tension. If the frequency is 200 Hz and the wavelength is 2.0 m, find the linear density of the string.*

11. *a.* ***Yes*** *b.* ***No*** *c.* ***Yes***

12. $v = 10\frac{m}{s}, 40\ s$

$v = \frac{\lambda}{T}$

$10\frac{m}{s} = \frac{\lambda}{40\ s}$

$\lambda = 10\frac{m}{s}(40\ s) = \mathbf{400\ m}$

13. $f = 30\ Hz, v = 60\frac{m}{s}$

$v = f\lambda$

$60\frac{m}{s} = 30\ Hz\ \lambda$

$\lambda = \mathbf{2\ m}$

14. $A = \mathbf{4\ cm}, \boldsymbol{\lambda = 6\ cm}, \boldsymbol{f = 0.83\ Hz}$

$v = f\lambda = f \cdot 6\ cm = 5\frac{cm}{s}$

15. $t = 20\ s (t = 10\ s\ for\ one\ way), v = 1522\frac{m}{s}$

$x = vt$

$x = 1522\frac{m}{s}(10\ s) = \mathbf{15220\ m}$

16. $5\ m, I = 200\frac{W}{m^2}$

$10\ m, I = ?$

$I = \frac{P}{A}, A = 4\pi r^2$

$200\frac{W}{m^2} = \frac{P}{4\pi(5\ m)^2} \rightarrow P = 62832\ W$

$I = \frac{62832\ W}{4\pi(10\ m)^2} = \mathbf{50\ W/m^2}$

17. $\beta = 120\ dB, I_0 = 10^{-12}\frac{W}{m^2}$

$\beta = (10\ dB)\ log\left(\frac{I}{I_0}\right)$

$120\ dB = (10dB)\ log\left(\frac{I}{10^{-12}\frac{W}{m^2}}\right)$

$12 = log\left(\frac{I}{10^{-12}\frac{W}{m^2}}\right)$

$10^{12} = \frac{I}{10^{-12}\frac{W}{m^2}}$

$\boldsymbol{I = 1.0\ W/m^2}$

18. $f_s = 440\ Hz, f_0 = 330\ Hz, v = 343\frac{m}{s}$

$f_0 = f_s\left(\frac{v_w \pm v_o}{v_w \mp v_s}\right)$

$330\ Hz = 440\ Hz\left(\frac{343\frac{m}{s} - v_o}{343\frac{m}{s} + 0}\right)$

$0.75 = \frac{343\frac{m}{s} - v_o}{343\frac{m}{s}}$

$257.25\frac{m}{s} = 343\frac{m}{s} - v_o$

$\boldsymbol{v_0 = 85.8\frac{m}{s}}$

19. $v_0 = 50\frac{m}{s}, v_s = 10\frac{m}{s}, f_s = 200\ Hz$

$f_0 = f_s\left(\frac{v_w \pm v_o}{v_w \mp v_s}\right)$

$f_0 = 200\ Hz\left(\frac{343\frac{m}{s} + 50\frac{m}{s}}{343\frac{m}{s} - 10\frac{m}{s}}\right) = \mathbf{236\ Hz}$

20. $|f_g - 440\ Hz| = 10\ Hz$

$f_g = \mathbf{450\ Hz}\ or 430\ Hz$

$|f_g - 445\ Hz| = 5\ Hz$

$f_g = \mathbf{450\ Hz}\ or 440\ Hz$

21. $L = 2\ m, n = 4, v = 40\frac{m}{s}, f = ?$

$f_n = n\left(\frac{v}{2L}\right)$

$f_4 = 4\left(\frac{40\frac{m}{s}}{2(2\ m)}\right) = \mathbf{40\ Hz}$

22. $L = 2\ m, n = 1, v = 40\frac{m}{s}$

$f_n = n\left(\frac{v}{2L}\right)$

$f_1 = 1\left(\frac{40\frac{m}{s}}{2(2\ m)}\right) = \mathbf{10\ Hz}$

23. $f_1 = 440\ Hz, n = 1, v = 343\frac{m}{s}$

$f = n\left(\frac{v}{2L}\right)$

$440\ Hz = 1\left(\frac{343\frac{m}{s}}{2L}\right)$

$440\ Hz = \frac{171.5\frac{m}{s}}{L}$

$L = \frac{171.5\frac{m}{s}}{440\ Hz} = \mathbf{0.390\ m}$

24. $F = 15\ N, x = -0.03\ m$

$F = -kx$

$15\ N = -k(-0.03\ m)$

$\mathbf{500\ \frac{N}{m}} = k$

25. $F = 100\ N, f = 200\ Hzs, \lambda = 2.0\ m$

$v = f\lambda$

$v = (200\ Hz)(2.0\ m) = 400\frac{m}{s}$

$v = \sqrt{\frac{F}{m/L}}$

$400\frac{m}{s} = \sqrt{\frac{100\ N}{m/L}}$

$160000\frac{m^2}{s^2} = \frac{100\ N}{m/L}$

$m/L = \frac{100\ N}{160000\frac{m^2}{s^2}} = \mathbf{6.25 \times 10^{-4}\ kg/m}$

Physics

Unit 8: Electric Forces and Electric Fields

1. *What is the charge of an electron?*
2. *What is the value of k?*
3. *What are some combinations of charges that attract? Repel?*
4. *Know the steps to charge by contact and by induction.*
5. *Definitions: electric potential difference, electric potential energy, capacitor, dielectric, equipotential lines, electric field, electric field lines, conductors, insulators*
6. *Is electric force conservative?*
7. *A piece of wire has a charge of* -3.2×10^{-5} *C. How many extra electrons does it have?*
8. *At what separation will two charges, each of magnitude 10.0 μC, exert a force of 5 N on each other?*
9. *A -10.0-μC charge is located 0.50 m to the right of a +15.0-μC charge. What is the magnitude and direction of the electrostatic force on the positive charge?*
10. *Know about the electric field in a parallel plate capacitor.*
11. *How is the spacing of the electric field lines related to the strength?*
12. *How is the number of electric field line related to the size of the charge?*
13. *Where are the excess charges on a conductor located?*
14. *What is the magnitude and direction of the electric force on a +5 μC charge at a point where the electric field is 5000 N/C and is directed on the –x axis?*
15. *The electric potential at a certain point in space is 6 V. What is the electric potential energy of a -4 C charge placed at that point in space?*
16. *If a 2-C charge is located at the origin and a -3-C charge is located at x = 2 m, where is the electric potential zero?*
17. *If the work required to move a -0.25 C charge from point A to point B is +100 J, what is the potential difference between the two points? What is the difference in potential energies of A and B?*
18. *Given a picture of a equipotential lines, be able to find area of greatest electric potential energy and electric field strength.*
19. *A capacitor has a very large capacitance of 100 F. The capacitor is charged by placing a potential difference of 3 V between its plates. How much energy is stored in the capacitor?*

1. $-1.60 \times 10^{-19}\ C$
2. $8.99 \times 10^{9}\ \frac{Nm^2}{C^2}$
3. *Attract: +,-; +,0; -,0; Repel: +, +; -, -*
4. *See textbook or notes*
7. $\frac{-3.2\times10^{-5}\ C}{-1.60\times10^{-19}\ C} = \mathbf{2.0 \times 10^{14}\ electrons}$
8. $F = k\frac{|q_1 q_2|}{r^2}$

   $5\ N = \left(8.99 \times 10^{9}\frac{Nm^2}{C^2}\right)\frac{|(10 \times 10^{-6}\ C)(10 \times 10^{-6}\ C)|}{r^2}$

   $r^2 = \left(8.99 \times 10^{9}\frac{Nm^2}{C^2}\right)\frac{|(10 \times 10^{-6}\ C)(10 \times 10^{-6}\ C)|}{5\ N}$

   $r^2 = 0.1798\ m^2$

   $\boldsymbol{r = 0.424\ m}$
9. $F = k\frac{|q_1 q_2|}{r^2}$

   $F = \left(8.99 \times 10^{9}\frac{Nm^2}{C^2}\right)\frac{|(-10 \times 10^{-6}\ C)(15 \times 10^{-6}\ C)|}{(0.5\ m)^2}$

   $\boldsymbol{F = 5.39\ N\ to\ the\ right}$
10. *Constant, etc.*
11. *Wider space, less field*
12. *More lines, more charge*
13. *On surface*
14. $E = \frac{F}{q}$

    $-5000\frac{N}{C} = \frac{F}{5 \times 10^{-6}\ C}$

    $F = -0.025\ N$

    0.025 *N* in the -*x* direction
15. $V = \frac{EPE}{q_0}$

    $6\ V = \frac{EPE}{-4\ C}$

    $\boldsymbol{EPE = -24\ J}$
16. $V = \frac{kQ}{r}$

    $\frac{k(2\ C)}{x} + \frac{k(-3\ C)}{2-x} = 0$

    $\frac{(2-x)k(2\ C)}{x(2-x)} + \frac{xk(-3\ C)}{x(2-x)} = 0$

    $(2-x)(2\ C) + x(-3\ C) = 0$

    $4\ C - (2\ C)x - (3\ C)x = 0$

    $4\ C = (5\ C)x$

    $\boldsymbol{x = 0.8\ m}$
17. $V_B - V_A = \frac{EPE_B}{q_0} - \frac{EPE_A}{q_0} = \frac{-W_{AB}}{q_0}$

    $V_B - V_A = \frac{-W_{AB}}{q_0}$

    $V_B - V_A = \frac{-100\ J}{-0.25\ C} = \mathbf{400\ V}$

    $W_{AB} = -W_{BA} = \mathbf{-100\ J}$
18. *EPE: electron has highest EPE at lowest V and proton has highest EPE at highest V*
    E-field: highest at place where equipotential lines are closest together
19. $E_{cap} = \frac{CV^2}{2}$

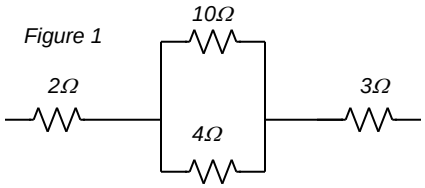
    $E_{cap} = \frac{(100\ F)(3\ V)^2}{2} = \mathbf{450\ J}$

Physics

Unit 9: Electric Circuits

1. *What is emf, kWh, rms, current, resistance, resistivity, and potential difference?*
2. *How do you use ammeters and voltmeters?*
3. *Know what factors your body's sensitivity to electricity?*
4. *Use Kirchhoff's Laws to solve problems.*
5. *A 2-A current flows through a circuit. How much charge passes a point during 1 minute?*
6. *A flashlight bulb is connected to a 3.0 V battery and a current of .020A flows. What is the resistance of the bulb's filament?*
7. *The resistivity of a metal is $3x10^{-8}$ Ωm. The radius of the wire is 2 mm. If the length of the wire is 3 m, what is the resistance of the wire?*
8. *A 2-A current flows through a circuit with a resistance of 5Ω. How much energy is dissipated in 3 s?*
9. *A 2-A current flows through a circuit that consists of a resistor and an ideal battery. If the battery supplies 400 W, how large is the resistor?*
10. *An AC voltage has a rms value of 5.66. Determine the peak value of the voltage?*
11. *Three resistors, 2-Ω, 3-Ω, 4-Ω, are connected in series. What is the equivalent resistance of the series?*
12. *Two 10-Ω and four 30-Ω light bulbs are connected in series with a 9 V battery. What is the current that passes through each bulb?*
13. *Three resistors, 2-Ω, 3-Ω, 4-Ω, are connected in parallel. What is the equivalent resistance of the combination?*
14. *What is the equivalent resistance of figure 1*

Figure 1



15. *A non-ideal battery has a 12.0 V emf and internal resistance of 4Ω. Determine the terminal voltage of the battery when 2 A is drawn.*
16. *An uncharged 10 F capacitor and a resistor are connected in series to a 9 V battery and an open switch to form a simple RC circuit. The switch is closed at t = 0s. The time constant of the circuit is 30 s. A) How big is the resistor and B)what is the maximum charge on the capacitor?*

5. $I = \frac{q}{t}$
   $2A = \frac{q}{60\ s}$
   $\boldsymbol{q = 120\ C}$
6. $V = IR$
   $3\ V = (0.02\ A)R$
   $\boldsymbol{R = 150\ \Omega}$
7. $R = \rho\left(\frac{L}{A}\right)$
   $A = \pi r^2 = \pi(0.002\ m)^2 = 1.256 \times 10^{-5}\ m^2$
   $R = (3 \times 10^{-8}\ \Omega m)\left(\frac{3\ m}{1.256 \times 10^{-5}\ m^2}\right) = \boldsymbol{7.16 \times 10^{-3}\ \Omega}$
8. $P = I^2R$
   $P = (2\ A)^2(5\ \Omega) = 20\ W$
   $P = \frac{W}{t}$
   $20\ W = \frac{W}{3\ s}$
   $\boldsymbol{W = 60\ J}$
9. $P = I^2R$
   $400\ W = (2\ A)^2R$
   $\boldsymbol{R = 100\ \Omega}$
10. $V_{rms} = \frac{V}{\sqrt{2}}$
    $5.66\ V = \frac{V}{\sqrt{2}}$
    $\boldsymbol{V = 8.0\ V}$
11. $R_S = R_1 + R_2 + R_3$
    $R_S = 2\ \Omega + 3\ \Omega + 4\ \Omega = \boldsymbol{9\ \Omega}$
12. $R_S = R_1 + R_2 + R_3 + R_4 + R_5 + R_6$
    $R_S = 2 \cdot (10\ \Omega) + 4 \cdot (30\ \Omega) = 140\ \Omega$
    $V = IR$
    $9\ V = I(140\ \Omega)$
    $\boldsymbol{I = 6.43 \times 10^{-2}\ A}$
13. $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
    $\frac{1}{R_P} = \frac{1}{2\ \Omega} + \frac{1}{3\ \Omega} + \frac{1}{4\ \Omega}$
    $\frac{1}{R_P} = \frac{6}{12\ \Omega} + \frac{4}{12\ \Omega} + \frac{3}{12\ \Omega} = \frac{13}{12\ \Omega}$
    $\boldsymbol{R_P = \frac{12}{13}\ \Omega}$
14. *Combine Parallel (middle)*
    $\frac{1}{R_P} = \frac{1}{10\ \Omega} + \frac{1}{4\ \Omega} = \frac{7}{20\ \Omega}$
    $R_P = \frac{20}{7}\Omega$
    Combine Series
    $R_S = 2\ \Omega + \frac{20}{7}\ \Omega + 3\ \Omega = \boldsymbol{\frac{55}{7}\ \Omega}$
15. *Internal*
    $V = IR = (2\ A)(4\ \Omega) = 8\ V$
    Terminal
    $terminal = emf - internal$
    $12\ V - 8\ V = \boldsymbol{4\ V}$
16. *a.* $\tau = RC$
    $30\ s = R(10\ F)$
    $\boldsymbol{R = 3\ \Omega}$
    b. $Q = CV$
    $Q = (9\ V)(10\ F) = \boldsymbol{90\ C}$

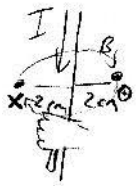
Physics

Unit 10: Magnetism

1. *Know the fundamental properties of permanent magnets.*
2. *Know how to induce emf.*
3. *Know the RHR's, and Lenz's Law.*
4. *A solenoid that is 2 m long and has a diameter of 0.5 m has 150 turns. Find the magnitude and direction of the magnetic field at the center of the solenoid if the current is 5 A clockwise.*
5. *A straight wire carries 5 A of current. If the wire is vertical and the current runs down, find the magnitude and direction of the magnetic field 2 cm from the wire.*
6. *A loose proton enters a magnetic field whose direction is coming out of the page. What does its path look like? If the path is bent, what way does it bend?*
7. *The path of a charged particle is bent clockwise in a magnetic field that is pointed out of the page. What is sign of the charge of the particle?*
8. *The force on a 3 cm wire that carries 10 A is 0.051 N. The wire is in a 0.5 T magnetic field. What is the angle between the wire and the magnetic field?*
9. *A current goes down and the magnetic field points to the right. What is the direction of the force on the wire carrying the current?*
10. *A single circular loop of wire is in a 0.5 T B-field. The normal makes an angle of 30° with the B-field. If there is a 5 A current in the loop (r = 5 cm), what is the torque on the loop?*
11. *Two wires are side by side and very close to each other. One wire carries 2 A and the other 3A in the same direction. What is magnetic field 5 cm from the wires?*
12. *A circular loop of wire (r = 5 cm) is in a magnetic field (B = 0.5 T) with the normal of the loop parallel to the B-field. The B-field increases at a rate of 0.1 T/s. What is the induced emf in the loop? What direction would a current flow through the loop?*
13. *A transformer's primary coil has 160 turns and 240 V. How many turns are needed in the secondary coil to get 80 V? Is this a step-up or step-down transformer?*
14. *A solenoid with 10 turns has a cross-sectional area of 2.0 cm^2 and length of 5 cm. How much energy is stored in the magnetic field of the solenoid when it carries a current of 5.0 A?*
15. *Two coils share a common axis. The mutual inductance of this pair of coils is 10.0 mH. If the current in coil **1** is changing at the rate of 10 A/s, what is the magnitude of the emf generated in coil **2**?*

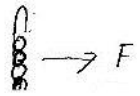
4. $L = 2\ m, d = 0.5\ m, N = 150, I = 5\ A$
$B = \mu_0 nI; n = \frac{N}{L} = \frac{150}{2\ m} = 75\ m^{-1}$
$B = \left(4\pi \times 10^{-7}\frac{Tm}{A}\right)(75\ m^{-1})(5\ A) = \mathbf{4.71 \times 10^{-4}\ T}$
RHR says points ***into paper***

5. $I = 5\ A, r = 0.02\ m$
$B = \frac{\mu_0 I}{2\pi r}$
$B = \frac{\left(4\pi \times 10^{-7}\frac{Tm}{A}\right)(5\ A)}{2\pi(0.02\ m)} = \mathbf{5 \times 10^{-5}\ T}$
Goes in on left, out on right



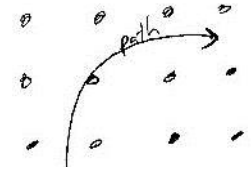
6. *Since the proton is charged, the path is bent.*

RHR – fingers
- thumb in direction of v
- palm points in direction of F



Bends to right *(electron would bend left)*

7. ***Positive***

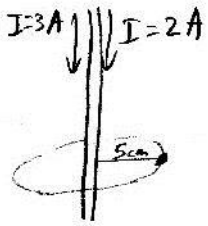


8. $L = 0.03\ m,\ I = 10\ A, F = 0.051\ N, B = 0.5\ T$
$F = ILB\sin\theta$
$0.051\ N = (10\ A)(0.03\ m)(0.5\ T)\sin\theta$
$0.34 = \sin\theta$
$\boldsymbol{\theta = 19.9°}$
9. *RHR – fingers B*
- thumb I
- palm F

F is out of page

10. $N = 1, B = 0.5\ T,\ \theta = 30°,\ I = 5\ A, r = 0.05\ m$
$\tau = NIAB\sin\theta$
$\tau = 1(5\ A)(\pi(0.05\ m)^2)(0.5\ T)\sin 30° =$
$\mathbf{0.00982\ Nm}$

11. *Ampere's Law*



$B = \frac{\mu_0 I}{2\pi r}$
$B(2\pi 0.05\ m) = \left(4\pi \times 10^{-7}\frac{Tm}{A}\right)(3\ A + 2\ A)$
$B(0.31416\ m) = 6.2832 \times 10^{-6}\ Tm$
$\boldsymbol{B = 2 \times 10^{-5}\ T}$

12. $N = 1, r = 0.05\ m, B = 0.5\ T, \frac{\Delta B}{\Delta t} = 0.1\frac{T}{s}$
$emf = -N\frac{\Delta\Phi}{\Delta t}, \Phi = BA\cos\theta$
$emf = -1 \cdot \frac{B_f A\cos 0 - B_0 A\cos 0}{\Delta t}$
$emf = -\left(\frac{A(B_f - B_0)}{\Delta t}\right)$
$emf = -\left(A\frac{\Delta B}{\Delta t}\right)$
$emf = -(\pi(0.05\ m)^2)\left(0.1\frac{T}{s}\right) = \mathbf{-7.85 \times 10^{-4}\ V}$
Flux is getting stronger so induced B-field should cancel the original B-field.
RHR – curl your fingers through the loop in the direction of the induced B-field. Your thumb will point the direction of the current.

13. $N_p = 160, V_p = 240\ V, V_s = 80\ V$
$\frac{V_s}{V_p} = \frac{N_s}{N_p}$
$\frac{80\ V}{240\ V} = \frac{N_s}{160}$
$N_s = 53.3$
54 turns; Step-down *since V decreases.*

14. $L = \frac{u_0 N^2 A}{\ell}$
$L = \frac{\left(4\pi \times 10^{-7}\frac{Tm}{A}\right)(10)^2(0.0002\ m^2)}{0.05\ m}$
$= 5.0265 \times 10^{-7}\ H$
$E_{ind} = \frac{1}{2}LI^2$
$E_{ind} = \frac{1}{2}(5.0265 \times 10^{-7}\ H)(5\ A)^2$
$= \mathbf{6.28 \times 10^{-6}\ J}$

15. $emf_1 = -M\frac{\Delta I_2}{\Delta t}$
$emf_1 = -(0.010\ H)\left(10\frac{A}{s}\right) = \mathbf{-0.100\ V}$

Physics

Unit 11: Electromagnetic Waves

1. *Know about the spectrum of light including the complete spectrum and visible light.*
2. *Know about the eye, vision correction, and color vision*
3. *Know how to make ray diagrams for mirrors and lenses.*
4. *What type of images to the various mirrors and lenses make? (real or virtual) (upright or inverted) (enlarged or reduced)*
5. *Why does refraction happen?*
6. *A spy satellite is in orbit at a distance of* 1.0×10^5 *m above the ground. It carries a telescope that can resolve the two rails of a railroad track that are 1.4 m apart using light of wavelength 500 nm. What is the size of the mirror in the telescope?*
7. *WAUS has a frequency of 90.7 MHz. What is it's wavelength?*
8. *An electromagnetic wave has a magnetic field with peak value 0.500 T. What is the average intensity of the wave?*
9. *If the index of refraction is 12.5, what is the speed of light in the material?*
10. *A beam of light in a material of index of refraction of 1.5 hits a boundary with air (n = 1.00). If the angle of incidence is 25°, what is the angle of refraction?*
11. *A 2 cm object is placed 15 cm from a lens. The resulting image height has a magnitude of 0.5 cm and the image is inverted. What is the focal length of the lens?*
12. *What is the image distance if an object is placed 10 cm in front of a concave mirror with radius of curvature of 12 cm?*
13. *Light with a 700nm wavelength is shown through a double slit. If the m = 0 and m = 1 bright fringes are separated by 10°, what is the separation of the slits?*
14. *Light with a700nm wavelength is shown through a single slit onto a screen 3 m away. What is the width of the slit if the 2nd-order dark fringe is located 50 cm from the center of the central bright region?*
15. *A diffraction grating has 2000 lines/cm and has monochromatic light shown on it. If the 3rd-order maximum is at 20°, what is the wavelength of the light?*
16. *A portion of a soap bubble appears to have* λ *= 500.0 nm in a vacuum when viewed at normal incidence in white light. Determine the smallest, non-zero thickness for the soap film if its index of refraction is 2.0.*
17. *Unpolarized light with an average intensity of 1000 W/m² enters a polarizer with a vertical transmission axis.*
    a. *What is the intensity of the light after the polarizer?*
    b. *Then the light hits a second polarizer. The light that exits the second polarizer has an intensity of 300 W/m². What is the orientation angle of the second polarizer?*

4. *Mirrors*
Concave: $d_o > R$ image real, inverted, reduced, between C and F
$f < d_o < R$ image real, inverted, enlarged, beyond C
$d_o < f$ image virtual, upright, enlarged, behind mirror
Convex: image virtual, upright, reduced, behind mirror

Lenses
Converging: $d_o > 2f$ image real, inverted, reduced, between 2F and F
$f < d_o < 2f$ image real, inverted, enlarged, beyond 2F
$d_o < f$ image virtual, upright, enlarged, behind lens
Diverging: image virtual, upright, reduced, behind lens

5. ***Speed of light changes***

6. $\theta = 1.22\frac{\lambda}{D}$
$tan\,\theta = \frac{1.4\ m}{1\times10^5\ m}$
$\theta = 0.000014$
$\theta = 1.22\frac{\lambda}{D}$
$0.000014 = 1.22\frac{500\times10^{-9}\ m}{D}$
$D = \mathbf{0.044\ m}$

7. $f = 90.7\times10^6\ Hz, c = 3.00\times10^8\frac{m}{s}$
$c = f\lambda$
$3.00\times10^8\frac{m}{s} = (90.7\times10^6 Hz)\lambda$
$\boldsymbol{\lambda = 3.31\ m}$

8. $I_{ave} = \frac{cB_0^2}{2\mu_0}$
$I_{ave} = \frac{\left(3.00\times10^8\frac{m}{s}\right)(0.500\ T)^2}{2\left(4\pi\times10^{-7}\frac{T}{Nm}\right)}$
$I_{ave} = \mathbf{2.98\times10^{13}\ W/m^2}$

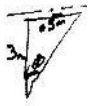
9. $n = 12.5$
$n = \frac{c}{v}$
$12.5 = \frac{3.00\times10^8\frac{m}{s}}{v}$
$\boldsymbol{v = 2.4\times10^7\frac{m}{s}}$

10. $n_1 = 1.5, \theta_1 = 25°, n_2 = 1.0, \theta_2 = ?$
$n_1\,sin\,\theta_1 = n_2\,sin\,\theta_2$
$1.5\,sin\,25° = 1.0\,sin\,\theta$
$0.6339 = sin\,\theta$
$\theta = sin^{-1}\,0.6339 = \mathbf{39.3°}$

11. $h_0 = 2\ cm, d_o = 15\ cm, h_i = -0.5\ cm, f = ?$
$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$
$\frac{-0.5}{2} = \frac{-d_i}{15}$
$-2d_i = -7.5$
$d_i = 3.75\ cm$
$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$
$\frac{1}{f} = \frac{1}{15} + \frac{1}{3.75}$
$\boldsymbol{f = 3\ cm}$

12. $R = 12\ cm, f = 6\ cm, d_o = 10\ cm$
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
$\frac{1}{6} = \frac{1}{10} + \frac{1}{d_i}$
$\frac{1}{6} - \frac{1}{10} = \frac{1}{d_i}$
$\boldsymbol{d_i = 15\ cm}$

13. $sin\,\theta = \frac{m\lambda}{d}$
$sin\,10° = \frac{1(700\times10^{-9}\ m)}{d}$
$d = 4.03\ \mu m = \mathbf{4.03\times10^{-6} m}$

14. $sin\,\theta = \frac{m\lambda}{W}$

$tan\,\theta = \frac{0.5}{3}$
$\theta = 9.46°$
$sin\,9.46° = \frac{2(700\times10^{-9}\ m)}{W}$
$\boldsymbol{W = 8.52\times10^{-6}\ m}$

15. $sin\,\theta = \frac{m\lambda}{d}$
$d = \frac{1}{2000\frac{lines}{cm}} = 0.0005\ cm = 0.000005\ m$
$sin\,20° = \frac{3\lambda}{0.000005\ m}$
$\boldsymbol{\lambda = 5.7\times10^{-7}\ m}$

16. *Only ray 1 phase shifts so to get constructive interference,* $2t = \frac{\lambda_n}{2}$
$\lambda_n = \frac{\lambda}{n} = \frac{500\times10^{-9}\ m}{2.0} = 250\times10^{-9}\ m$
$2t = \frac{250\times10^{-9}\ m}{2}$
$t = \mathbf{6.25\times10^{-8}\ m}$

17. *a.* $\mathbf{500\frac{W}{m^2}}$ *(halved)*
b. $S = S_0\,cos^2\,\theta$
$300\frac{W}{m^2} = 500\frac{W}{m^2}cos^2\,\theta$
$0.6 = cos^2\,\theta$
$0.7746 = cos\,\theta$
$\theta = cos^{-1}\,0.7746 = \mathbf{39.2°}$

Physics

Unit 12: Special Relativity

1. *Define inertial reference frame, proper time, dilated time, proper length, contracted length, relativistic momentum, nonrelativistic momentum,*
2. *Know the relativity postulates and their consequences.*
3. *An astronaut travels at $1x10^8$ m/s for 24 hours as measured by ground control. What is the time as measured by the astronaut?*
4. *An alien flies by a football game at 0.90c and measures the time it takes to kick a field goal as 0.50 s. What is the proper time for the kick?*
5. *A meter stick is measured to be 50 cm long. How fast must the meter stick be traveling?*
6. *What is the relativistic momentum of an electron traveling at 0.99c?*
7. *A car is 500 kg at rest. What is the increase in its energy when it is traveling at 0.90c?*
8. *How much energy will be released when 2 kg of pencil is converted to energy?*
9. *What is the ratio of relativistic kinetic energy to classical kinetic energy for a 500 kg car traveling at 0.90c?*
10. *The Enterprise moves at 0.9c relative to earth and the Klingon Bird-of-Prey moves at 0.7c relative to earth. What does the navigator of the Bird-of-Prey report for the speed of the Enterprise?*
11. *The Klingon Battle Cruiser moving at 0.7c relative to earth fires a torpedo at 0.5c relative to the Battle Cruiser. What is the speed of the torpedo as observed from earth?*
12. *The Klingon Battle Cruise approaches earth at 0.7c relative to earth. It passes the Ferengi Shuttle at 0.5c relative to the shuttle. What is the speed of the Shuttle relative to the earth?*
13. *The starship Enterprise approaches the planet Risa at a speed of 0.5c relative to the planet. On the way, it overtakes the intergalactic freighter Astra. The relative speed of the two ships as measured by the navigator on the Enterprise is 0.1c. If the Astra has a red (λ = 650 nm) navigation light, what wavelength will the Enterprise see as they approach the Astra.*

3. $\Delta t = 24\ h, v = 1 \times 10^8 \frac{m}{s},\ \Delta t_0 = ?$

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$24\ h = \frac{\Delta t_0}{\sqrt{1 - \frac{\left(1 \times 10^8 \frac{m}{s}\right)^2}{\left(3 \times 10^8 \frac{m}{s}\right)^2}}}$$

$$24\ h = \frac{\Delta t_0}{\sqrt{1 - \frac{1}{9}}}$$

$$24\ h \sqrt{\frac{8}{9}} = \Delta t_0$$

$$\boldsymbol{\Delta t_0 = 22.6\ h}$$

4. $v = 0.90c, \Delta t = 0.50\ s, \Delta t_0 = ?$

$$0.50\ s = \frac{\Delta t_0}{\sqrt{1 - \frac{(0.90c)^2}{c^2}}}$$

$$0.50\ s \sqrt{1 - 0.90^2} = \Delta t_0$$

$$\boldsymbol{\Delta t_0 = 0.218\ s}$$

5. $L_0 = 1\ m, L = 0.5\ m, v = ?$

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

$$0.5\ m = 1\ m \sqrt{1 - \frac{v^2}{c^2}}$$

$$0.25 = 1 - \frac{v^2}{c^2}$$

$$0.75 = \frac{v^2}{c^2}$$

$$v = \sqrt{0.75}c$$

$$\boldsymbol{v = 0.87c}$$

6. $v = 0.99c, m = 9.11 \times 10^{-31}\ kg, p = ?$

$$p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$p = \frac{(9.11 \times 10^{-31}\ kg)\left(0.99\left(3 \times 10^8 \frac{m}{s}\right)\right)}{\sqrt{1 - \frac{(0.99c)^2}{c^2}}}$$

$$\boldsymbol{p = 1.92 \times 10^{-21}\ kg\ m/s}$$

7. $m = 500\ kg, v = 0.90c, KE = ?$

$$KE = mc^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1\right)$$

$$KE = (500\ kg)(c^2)\left(\frac{1}{\sqrt{1 - \frac{0.90c^2}{c^2}}} - 1\right)$$

$$\boldsymbol{KE = 5.82 \times 10^{19}\ J}$$

8. $m = 2\ kg, E = ?$

$$E = mc^2$$

$$E = (2\ kg)\left(3 \times 10^8 \frac{m}{s}\right)^2$$

$$\boldsymbol{E = 1.8 \times 10^{17}\ J}$$

9. $KE_{classic} = \frac{1}{2}mv^2$

$$KE_{classic} = \frac{1}{2}(500\ kg)\left(0.90\left(3 \times 10^8 \frac{m}{s}\right)\right)^2$$

$$KE_{classic} = 1.82 \times 10^{19}\ J$$

$KE_{relativistic} = 5.82 \times 10^{19}\ J$ *(see #7)*

$$ratio = \frac{5.82 \times 10^{19}\ J}{1.82 \times 10^{19}\ J} = \boldsymbol{3.20}$$

10. $v_{EntE} = 0.9c, v_{KE} = 0.7c, v_{EntK} = ?$

$$v_{EntK} = \frac{v_{EntE} + v_{EK}}{1 + \frac{v_{EntE} v_{EK}}{c^2}}$$

$$v_{EntK} = \frac{0.9c + -0.7c}{1 + \frac{(0.9c)(-0.7c)}{c^2}}$$

$$\boldsymbol{v_{EntK} = 0.541c}$$

11. $v_{KE} = 0.7c, v_{TK} = 0.5c, v_{tE} = ?$

$$v_{TE} = \frac{v_{TK} + v_{KE}}{1 + \frac{v_{TK} v_{KE}}{c^2}}$$

$$v_{TE} = \frac{0.5c + 0.7c}{1 + \frac{(0.7c)(0.5c)}{c^2}}$$

$$\boldsymbol{v_{TE} = 0.889c}$$

12. $v_{KE} = 0.7c, v_{KS} = 0.5c, v_{SE} = ?$

$$v_{SE} = \frac{v_{SK} + v_{KE}}{1 + \frac{v_{SK} v_{KE}}{c^2}}$$

$$v_{SE} = \frac{-0.5c + 0.7c}{1 + \frac{(-0.5c)(0.7c)}{c^2}}$$

$$\boldsymbol{v_{SE} = 0.308c}$$

13. $u = -0.1c, \lambda_s = 650\ nm$

$$\lambda_{obs} = \lambda_s \left(\frac{1 + \frac{u}{c}}{1 - \frac{u}{c}}\right)$$

$$\lambda_{obs} = (650\ nm)\left(\frac{1 + \frac{-0.1c}{c}}{1 - \frac{-0.1c}{c}}\right) = \boldsymbol{531\ nm}$$